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Ocular Manifestations of Vitamin A Deficiency among the Rural Pre-School Children of North India

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Abstract

Purpose: Vitamin A deficiency (VAD) is still a major nutritional problem of public health importance among the rural pre-school children in India, even after the implementation national vitamin A prophylaxis programme for prevention of nutritional blindness and ICDS have been in operation for more than three decades. The purpose of this communication is to assess the prevalence of ocular manifestations of vitamin A deficiency among rural pre-school children of north India.

Methods: A community based cross-section study; adopting multi-stage random sampling procedure was carried out by NNMB among rural pre-school children of four north Indian states viz. Maharashtra, Madhya Pradesh, Orissa and West Bengal. A total of 36,111 rural pre-school children of 1-5years (Boys: 18408; Girls: 17703) were covered for this study.

Results: The prevalence of conjunctival xerosis (2.5%), the first ocular sign of VAD and Bitot's spot (0.9%), an objective ocular sign of VAD was higher than the cut-off values suggestive of public health nutritional problem among the rural children. While, the prevalence of night blindness, the first symptom VAD was reported among 0.5% of rural children. Similarly, the proportion of rural pre-school children with sub-clinical VAD was 64%, suggestive of severe public health importance.

Conclusion:

The prevalence of ocular manifestation and sub-clinical vitamin A deficiency was high among the rural children of north India. Therefore, rural communities are encouraged to consume diets rich in vitamin A and administer massive dose vitamin A solution to the children of under five for the prevention and control of vitamin A deficiency and its adverse impact on child morbidity and mortality.

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Introduction:

Micronutrient deficiencies (MND) are the major nutritional problems of public health significance in the developing countries, adversely affecting the people's health and their economic development[1]. The World Bank estimated combined economic costs of vitamin A deficiency (VAD), iron deficiency anaemia (IDA) and iodine deficiency disorders (IDD) in developing countries was about 5% of their gross domestic product (GDP).[2] Vitamin A is group of fat soluble retinoids such as retinol, retinal and retinyle esters[3,4] , which is an essential micronutrient required for normal functioning of the visual system, and maintenance of cell function for growth, epithelial integrity, red blood cell production, immunity, and reproduction[5,6] . Vitamin A is very essential nutrient for vision as an important component of rhodopsin, that absorbs light in the retinal receptors, and for the differentiation and functioning of the conjunctival membranes and cornea[4,6]. The ocular manifestations of VAD is called Xerophthalmia, which includes milder forms of Night blindness, Conjunctival Xerosis, and Bitot's Spots and severe forms of Corneal Xerosis, Corneal Ulceration and Keratomalacia[7].

Vitamin A deficiency is one of the most important causes of preventable childhood blindness and contributes to morbidity and mortality from infections, especially in children[5] and it also increases the severity and mortality risk of infections like diarrhoea and measles, even before the onset of xerophthalmia[5,8]. The prevalence of vitamin A deficiency (VAD) has been recognized as a public-health nutritional problem in developing countries[9], which could be attributed to limited access to foods containing pre-formed vitamin A (Retinol) from animal-based food sources and poor consumption of foods containing beta-carotene due to poverty and food choices[4]. As per the World Health Organizatioan (WHO) estimates, approximately one-third of the world's pre-school children are vitamin A deficient and most of them live in South East Asia (91.5 million) with highest proportion of the world's VAD children are from India[5,10,11]. Similarly, West Jr also reported that the largest number of sub-clinical vitamin A deficient children lives in India and 40% of all pre-school children with xerophthalmia (pathologic dryness of the conjunctiva and cornea) in the developing world live in India[12]. Thus, vitamin A deficiency continues to be a major public health nutritional problem in India[11], and as reported by the community-based studies, the prevalence of both clinical and sub-clinical VAD was high among pre-school children in rural India[13-15]. In general, the overall prevalence of xerophthalmia among children in India was reported as 1.7% [16] and approximately 0.8% of all children suffer from Bitot's spots[17]. While, the sub-clinical VAD is even more prevalent; with recent estimates (31–57%) placing India among the highest in the world[12,17] . Similarly, a study carried out in northern India State of Uttar Pradesh reported the high prevalence of xerophthalmia (9.1%) and Bitot's Spot (5.4 %) among pre-school children. This study even reported the severe forms of VAD such as corneal ulceration and corneal scar as 0.2% and 0.5%, respectively[18]. Likewise, a higher prevalence of clinical VAD has been reported even among urban children of North Indian state of Gujarat (Bitot's Spot 2.1%). Therefore, keeping in view the magnitude of Vitamin A deficiency among the rural pre-school children of India, this communication was prepared with the objective to assess the prevalence of ocular manifestations of vitamin A deficiency among the rural pre-school children of four north Indian states, utilizing large data base collected by the National Nutrition Monitoring Bureau (NNMB).

Materials and Methods

A community based cross-section study; adopting multi-stage random sampling procedure was carried out by the NNMB among rural pre-school children of four north Indian states viz. Maharashtra, Madhya Pradesh, Orissa

and West Bengal. Each State was divided into 16 Strata based on agro-climatic characteristics. A district or part of a district with a population of 1.8 million was considered as one stratum. A total of 80 villages @ five villages per stratum were selected randomly from 16 strata, for the study. The list of villages covered for the 54th round of the consumer expenditure survey conducted by the National Sample Survey Organization[19] formed the sampling frame.

Estimation of Sample

Considering the prevalence of Bitot's spots among the pre-children as 1% (NNMB 1999), confidence interval (CI) of 95% and relative precision of 20%, a sample size of 9508 pre-children was arrived at for each State for the clinical examination to detect clinical signs of VAD. Whereas, a sub-sample of 576 pre-children was arrived at for each state, assuming the prevalence of blood vitamin A (<20 µg dL) deficiency among the pre-school children as 50% [20], 95% of CI and relative precision of 10%.

Selection of Children

The number of children to be covered from each randomly selected village was determined by the Probability Proportional to Size (PPS) sampling method. For this purpose, each selected village was divided into five geographical areas, based on a natural group of houses or streets. The households belonging to Scheduled Caste (SC)/Scheduled Tribe (ST) communities, who generally live as a separate group, constituted one of the five areas. The households with at least one pre-school child and the total number of pre-school children in each geographical area were enumerated. The total number of pre-school children to be covered from each village and the required number of pre-school children to be covered in each geographical area was determined based on the PPS method.

We obtained information regarding the households' demographic and socio-economic particulars and clinical examination was performed to detect the presence of clinical signs of VAD among 1-5-year-old children. We also collected the history of night blindness among the pre-school children from their parents/grand parents by asking whether their children had any difficulty in playing and/or identifying things/toys in dim light, especially at sunset. A free-falling drop of blood from finger-prick was collected on a pre-coded special chromatography filter paper (Whatman) to estimate blood vitamin A in a sub-sample of children covered for clinical examination by the dry blood spot (DBS) method[21].

Ethics: The study was approved by the scientific advisory committee (SAC) of Indian Council of Medical Research (ICMR), New Delhi and necessary ethical clearance was obtained before initiation of study from the Ethical Review Board (ERB) of National Institute of Nutrition, Hyderabad. Written informed consent was also obtained from the parents of pre-school children.

Training of the Field Staff

Each state unit comprising of medical officers, nutritionists and social workers were trained at a central reference laboratory (CRL) of NNMB at National Institute of Nutrition (NIN), Hyderabad for 3 weeks in identification of clinical signs of VAD and collection of dried blood spots (DBS), packing, storing and transporting the same from the field to the laboratory. Scientists from the National Institute of Nutrition supervised the data collection and re-examined a sub-sample of the data to ensure the quality.

Statistical Analysis

The Statistical Package for Social Sciences[22] was used for the analysis of data. The prevalence of ocular manifestations of VAD by state, age group and gender was analysed. Univariate and bivariate analysis was performed by the chi-square (x^2) test to study the association between the prevalence of Bitot's spots and

different socio-demographic variables. P value of <0.05 was considered as statistically significant.

The Definition for the 'community' mentioned in the Text:

Community (Caste): The Indian community is categorized into four major castes based on their occupations. They include socially underprivileged and economically underdeveloped poorer sections of the society i.e. Scheduled Caste (SC) & Scheduled Tribes (ST), Backward Caste (Different artisans come under this category) and Forward Caste. Generally, the Forward Caste communities are socially highly privileged and economically well off. The Scheduled Caste and Scheduled Tribe communities are provided with certain social and economic guarantees by the government of India.

Results

A total of 36,111 rural pre-school children of 1-5years (Boys: 18408; Girls: 17703) was covered for this study. The prevalence of ocular manifestations of VAD by states and gender is presented in **Table-1**. In general, the prevalence of night blindness, the early symptom of VAD was reported among 0.5% of children and the prevalence was more than the cut-off level of 1% in the state of Maharashtra, indicating the public health problem. While, the prevalence of conjunctival xerosis, the first clinical sign of VAD was observed among 2.5% of rural pre-school children of north India, ranging from a low 0.3% in the state of Orissa to a high 4.9% in the state of Madhya Pradesh. While, the prevalence of Bitot's spot, an objective clinical sign of VAD (0.9%) higher than the WHO (1996) cut-off of 0.5% indicating VAD as a public health problem among pre-school children. Barring in the state of Orissa, the prevalence of Bitot's spot was a public health problem in rest of the states ($p<0.001$). In general, the proportion of children with total VAD was 3.1%. The prevalence of conjunctival xerosis, Bitot's spots and total VAD was significantly higher among boys as compared to girls ($p<0.05$).However, the severe forms of clinical signs of VAD were not reported among the rural children of north India.

The prevalence of Bitot's spots, total VAD and sub-clinical VAD among rural pre-school children of north India by age group is presented in **Table-2**. The prevalence of Bitot's spots and total VAD increased significantly ($p<0.001$) with increasing age. The mean blood vitamin A levels were below 20µg/dL among the children of all the age groups. While the prevalence of

Table: 1. Prevalence of ocular manifestations of VAD among rural pre-school children of north India by states and gender

State	n	Night blindness	Conjunctival xerosis	Bitot's spots	VAD†
Maharashtra	8646	1.1 (0.9-1.3)	1.3 (1.1-1.5)	1.3 (1.1-1.5)	1.9 (1.6-2.2)
MP*	8777	0.8 (0.6-1.0)	4.9 (4.5-5.4)	1.4 (1.2-1.7)	6.6 (6.1-7.1)
Orissa	9460	0.1 (0.0-0.2)	0.3 (0.2-0.4)	0.3 (0.2-0.4)	0.4 (0.3-0.5)
West Bengal	9228	0.2 (0.1-0.3)	3.7 (3.3-4.1)	0.6 (0.4-0.8)	3.8 (3.4-4.2)
Pooled	36111	0.5 (0.4-0.6)	2.5 (2.2-2.7)	0.9 (0.8-1.0)	3.1 (2.9-3.3)
p-value	-	p<0.001	p<0.001	p<0.001	p<0.001
Gender					
Boys	18408	0.6 (0.5-0.7)	2.9 (2.7-3.1)	1.0 (0.9-1.1)	3.5 (3.2-3.8)
Girls	17703	0.5 (0.4-0.6)	2.2 (2.0-2.4)	0.8 (0.7-0.9)	2.8 (2.6-3.0)
p-value		0.295	<0.001	0.023	<0.001

* MP: Madhya Pradesh †: VAD: Total Vitamin A Deficiency

sub
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Table: 2. Prevalence of Bitot's spots and total and sub-clinical VAD among rural pre-school children of north India by age group

Age (Yrs)	Clinical VAD			Sub-Clinical VAD		
	n	Bitot's spots	VAD†	n	Mean (SD)	(<20µg/dL)
1+	6935	0.1 (0.0-0.2)	0.2 (0.1-0.3)	285	18.4 (10.15)	61.4 (55.8-67.1)
2+	8286	0.5 (0.4-0.7)	1.6 (1.3-1.9)	488	17.6 (10.29)	63.3 (59.0-67.6)
3+	8465	0.8 (0.6-1.0)	3.0 (2.6-3.4)	558	18.0 (9.91)	63.3 (59.3-67.3
4+	12425	1.7 (1.5-1.9)	5.9 (5.5-6.3)	704	17.2 (9.09)	66.2 (62.7-69.7)
Pooled	36111	0.9 (0.8-1.0)	3.1 (2.9-3.3)	2035	17.7 (9.77)	64.0 (61.9-66.1
p-value	-	<0.001	p<0.001		0.064	0.469

†: VAD: Total Vitamin A Deficiency

clinical was reported among 64% of rural pre-school children of north India, which was higher than the WHO cut-off level of ≥20%, suggestive of VAD as a severe public health problem. However, the prevalence was significantly not different between age groups (p>0.05).

The association between the prevalence of Bitot's spots and socio-demographic particulars is presented in **Table -3**. The prevalence of Bitot's spots was significantly (p<0.000) higher among the children belonged to socio-economically marginalized sections of the communities such as Scheduled Caste (SC) and Scheduled Tribe (ST). Similarly, significantly (p<0.05) a higher proportion of children belonged to Buddhists had Bitot's spots (1.7%) as compared to the children of other religions. Thus, the prevalence of Bitot's spots was significantly (p<0.000) high among the children of labourers, illiterate mothers and the households where the sanitary latrine was absent (p<0.000).

Discussion

The NNMB, for the first time carried out this community based study to assess the prevalence of ocular manifestations of VAD among rural children of four north Indian states by covering large state representative sample. In general, the prevalence of ocular signs of vitamin A deficiency among the rural children of north India is higher than the WHO cut-off levels suggestive of VAD as a public health problem. While, the prevalence of Bitot's spot an objective ocular clinical sign of VAD was significantly higher among the rural children residing in the states of Madhya Pradesh and Maharashtra as compared to the children of Orissa and West Bengal. The lower prevalence of Bitot's spots in the state of Orissa (0.3%) may perhaps be due to the large

Table: 3. The association between the prevalence of Bitot's spots and socio-demographic particulars

Variable	n	Bitot's spots (%)	p-value
Community			
ST†	6255	1.1	<0.001
SC*	7360	1.6	
OBC‡	12023	0.7	
Forward Caste	10473	0.4	
Religion			
Hindu	31935	0.9	0.03
Muslim	3644	0.5	
Christian	291	0.7	
Buddhist	241	1.7	
Occupation			
Laborers	15032	1.3	<0.001
Cultivators	11553	0.7	
Service/ Business	7414	0.5	
Artisans	2112	0.5	
Family size			
4-Feb	15777	0.7	<0.001
≥5	20334	1.1	
Female Literacy			
Illiterate	20882	1.1	<0.001
Literate	15169	0.6	
Sanitary latrine			
Absent	31589	1	<0.001
Present	4522	0.2	

ST†: Scheduled Tribes, SC*: Scheduled Caste, OBC‡: Other Backward Communities

coverage of children by the VAS programme as a special drive along with pulse polio immunisation during the period of the survey[17]. In general, significantly ($p<0.000$) a higher proportion of children of socio-economically marginalized SC and ST communities, labourer parents, illiterate mothers and those residing in the households where the facility of sanitary latrine was absent had Bitot's spots, suggestive of poor economic status and poor dietary consumption of vitamin A rich foods.

In developing countries, vitamin A deficiency typically begins during infancy, when infants do not receive adequate amounts of breast milk[5] and to some extent, discarding of colostrums by the mothers due to ignorance and faulty beliefs.VAD also begins to increase in young children just after they stop breastfeeding [23] which could be attributed poor and faulty feeding practices. In general, the amount of vitamin A in a well nourished lactating mother's breast milk is sufficient to meet infants' needs for the first 6 months of life. However, the women with vitamin A deficiency, the breast milk volume and vitamin A content are subopti-mal and not sufficient to maintain adequate vitamin A stores in infants who are exclusively breastfed[24]. This is more relevant in the Indian context, where a higher proportion of the rural women of reproductive age group were undernourished in terms of chronic energy

deficiency (BMI<18.5 kg/m^2) and multiple micronutrients deficiencies. It is evident from the periodic nutrition surveys carried out in rural areas of 10 major states of India by the NNMB in different time points, where, the dietary intakes of micronutrients particularly of vitamin A, iron, riboflavin and folic acid were largely deficit as against their recommended dietary allowances (RDAs) [25,26].

Vitamin A deficiency in pregnant and lactating women includes increased maternal and infant morbidity and mortality, increased anemia risk, and slower infant growth and development[27] and preterm infants with vitamin A deficiency have an increased risk of eye, chronic lung, and gastrointestinal diseases[28]. Similarly, pregnant women need extra vitamin A for fetal growth and tissue maintenance and for supporting their own metabolism[29]. Therefore, it is imperative to encourage the women of reproductive age group in general and pregnant and lactating women in particular to consume foods rich in multiple micronutrients to improve their micronutrient status, particularly of vitamin A content of breast milk of lactating mothers. This would facilitate to improve the vitamin A status and adequate vitamin A stores of children during their first two years of life. It is also important that the lactating mothers should feed colostrum and exclusively breastfed their infants for the first six months. However, as reported by UNICEF, only 46% of infants under six months are exclusively breastfed in India[30]. Therefore, lactating women should be sensitize about importance of breast feeding and encourage them to exclusively breastfed their infant for the first six months and continue to feed breast milk at least for two years together with nutritionally adequate, safe, age appropriate, responsive complementary feeding starting at six months. The sensitization should be done through health and nutrition education and behavioral change communication as about 58% mothers in this study area were illiterates.

Long term and sustainable food-based intervention is most appropriate for improving vitamin A status in general and in pre-school children in particular[31]. International Conference on Nutrition (ICN), World Declaration on Nutrition, and Plan of Action for Nutrition, emphasized that the priority should be given to food-based strategies, as this approach is the most effective to reduce micronutrient deficiencies in general and vitamin A deficiency in particular[32]. Latham also reiterated the importance of food-based approaches for prevention and control of VAD and emphasized the importance of exclusive breastfeeding, regular consumption of animal source foods (rich sources of retinol), leafy vegetables and fruits[33]. However, as per the NNMB secular trends in consumption of vitamin A rich foods such as green leafy and non-leafy vegetables and fruits were grossly deficit among the rural children of 1-5 years. Similarly, the consumption of animal source foods (fish and other flesh foods) was almost negligible; this could be attributed to poverty along with customs and taboos that prevail in Indian culture and tradition[31]. If we take into consideration of this existing food pattern among the rural children in India, it is extremely difficult to the rural children to meet the RDAs for majority of micronutrients, particularly with respect to vitamin A. In this context, Somer, a renowned nutrition expert on vitamin A expressed that food-based interventions have proved difficult to implement, and he also quoted the recent data and kinetic modelling that it is virtually impossible to correct widespread VAD by diet alone in developing countries, where populations remain dependent on conventional plant-based foods. He also quoted estimates from the studies carried out in developing countries that it takes 21 µg of β-carotene from typical vegetables and fruits and 27 µg of β-carotene from leafy vegetables to yield 1 µg of retinol (from the animal source foods) [34]. Therefore, we can assume that it is not possible for young children to consume sufficient quantities of vegetables and fruits to overcome the inefficiencies of β-carotene conversion.

The NNMB studies reported that the proportion of rural pre-school children in India not meeting even 50% of their suggested RDA for vitamin A (dietary median intakes) was 81% [25,26]. The conversion factor of 1:4 of retinol and β-carotene was used for calculation of vitamin A . If the revised Indian Council of Medical Research (ICMR) conversion factor of 1:8 is considered, the deficit would be even worse. Since the dietary consumption of vitamin A is grossly deficit among rural pre-school children in India, the flagship national nutrition programmes such as integrated child development services (ICDS) scheme and the mid-day meal (MDM) programme should strengthened and vitamin A rich foods to be included in daily menus of these supplementary nutrition programms. Similarly, the Government of India should take initiatives like control of prices food commodities, provision of safe drinking water, employment generation for rural poor, improving literacy status women, empowerment women, appropriate wages for daily labour etc. for improvement of nutritional status of the community both quantitatively and qualitatively.

We can also attribute the high prevalence of clinical and sub-clinical VAD poor coverage of pre-school children for the bi-annual massive dose vitamin A supplementation (VAS).The coverage of the bi-annual massive dose VAS ranged from a low 3.8% in the state of West Bengal to a high 41.2% in the state of Orissa as against the World Bank recommended ideal coverage of 85% for prevention and control of VAD and its impact on morbidity and mortality among children of under five. While, the proportion of children supplemented with at least one massive dose during the preceding one was highest in the state of Orissa (80%), followed by 52.6% in Madhya Pradesh and 52% each in the states of Maharashtra and West Bengal. The lower prevalence of Bitot spots in the state of Orissa may perhaps be due to the large coverage of children by the VAS programme as a special drive along with pulse polio immunisation during the period of the survey[17]. Thus, vitamin A supplementation could be considered as the most cost-effective short-term intervention for prevention and control of VAD. Periodic massive dose VAS programmes have been established over the past three decades in many developing countries to increase child survival and decrease the incidence of paediatric blindness[35]. Well-developed VAS programmes provide a reliable source of vitamin A for pre-school children in the face of economic instability and rising food prices[36] and the World Bank also reported that VAS was the second most cost-effective public health intervention in countries where VAD constitutes a public health problem[37]. Therefore, the existing VAS programme in India should be strengthened and compliance of the programme should be improved through health education to the community. It is also reiterated that the Pediatricians should also to encourage parents of under five children to administer stipulated nine massive doses of VA solution to their children along with the complete coverage of immunization.

Conclusion:

The high prevalence of ocular signs of vitamin A deficiency among the rural pre-school children of north India is a public health problem. Therefore, rural communities are encouraged to consume diets rich in vitamin A and administer massive dose vitamin A solution to the children of under five for the prevention and control of vitamin A deficiency and thereby its adverse impact on child morbidity and mortality.

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Conflicts of interest:

The authors declare that there are no conflicts of interest.

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